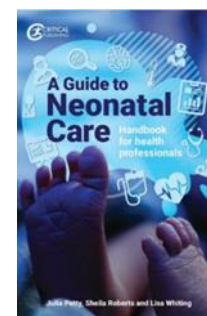


## Chapter 7 Altered anatomy and physiology of the neonate

*A Guide to Neonatal Care - Handbook for Health Professionals*  
Petty J, Whiting L and Roberts S (2024) Critical Publishing



### Supplementary information

Neonates that are admitted to neonatal care following delivery will be compromised in one or more of their biological systems for a variety of possible reasons, for example, premature birth, hypoxia, infection or trauma, all with a specific 'pathophysiology'; i.e. altered anatomy and physiology, compared to the 'norm' (see book, chapter 7). To add further detail to the chapter, an overview of common neonatal conditions requiring admission to a neonatal unit, with associated alterations in anatomy and physiology, is outlined in the following Figures [7.1 to 7.8].

**Figure 7.1 Summary of common respiratory conditions**

Condition	Description
<b>Respiratory distress syndrome [RDS]</b>	A condition more commonly seen in premature neonates caused by surfactant deficiency and immaturity of the lungs. Without adequate surfactant, the lungs may collapse which may lead to decreased gas exchange causing signs of respiratory inadequacy.
<b>Transient tachypnoea of the Newborn</b>	Is a condition where there is a delay in the clearance or reabsorption of foetal lung fluid. This condition often presents at birth and may subside within 24-48 hours, and rarely over 3-7 days
<b>Congenital respiratory infections</b>	Due to the immaturity of the immune system, newborns especially pre-term babies are at risk of developing respiratory infections, such as pneumonia. This could be acquired through the following routes: Ascending Route: which is associated with PROM; Aspiration of vaginal bacteria and Transplacental route. Can present early (within the first 48 hours of life) or late (after 48 hours of life).
<b>Meconium aspiration syndrome (MAS)</b>	MAS results from the passage of meconium into the amniotic fluid before birth. This will cause the foetus to inhale the meconium which can lead to the blockage of airways and cause inflammation within the lungs. Therefore, leading to decreased oxygenation of the blood with the newborn showing signs of respiratory distress. It usually takes 3-5 days to resolve.

<b>Persistent pulmonary hypertension</b>	Occurs when there is failure to lower the PVR at birth which leads to a continuous right-to-left shunting, hypoxaemia and acidosis.
<p><b>Diagnosis</b></p> <p>Common diagnostics for the common respiratory conditions are as follows:  C-Chest x-ray (Would usually be the determining factor to differentiate each of the conditions, see Figure 7.2)  A- Assessment (Physical)  L-Laboratory/ bloods (could often be useful to rule out infection)  M- Maternal history</p>	
<p><b>Respiratory assessment</b></p> <p>Signs of respiratory distress (are common for most of the respiratory conditions).</p> <p>H- Head bobbing  A- Apnoea  S- Slow, shallow breathing  T-Tachypnoea  I- Intercostal, subcostal, sternal recessions  N- Nasal flaring  G- Grunting / gasping.</p> <p>In addition to signs of respiratory distress (as above), neonates will also present with:</p> <ul style="list-style-type: none"> <li>• Altered behaviour or responsiveness.</li> <li>• Altered muscle tone.</li> <li>• Feeding difficulties / intolerance</li> <li>• Vital sign changes (HR, RR, and temperature),</li> <li>• Jaundice within &lt;24 hours of birth</li> <li>• Signs of encephalopathy</li> <li>• Unexplained excessive bleeding</li> <li>• Oliguria &gt;24 hours after birth</li> <li>• Altered glucose homeostasis.</li> </ul>	

### Management example - the neonate with RDS

- ✓ Maintain adequate oxygenation.
- ✓ Non-invasive respiratory support: CPAP, NIPPV, HFNC
- ✓ (If mechanical ventilation is imperative, then use volume-targeted ventilation mode) (NICE and European Consensus).
- ✓ Pharmacologic Therapy: Surfactant. Surfactant can be given either prophylactically/ as a rescue treatment and administered either through Minimally invasive surfactant treatment (MIST) or less invasive surfactant

administration (LISA) or the conventional INSURE method (intubate- give surfactant- extubate). MIST and LISA are only given to spontaneously breathing neonates using a specialised catheter.

- ✓ Antibiotic therapy.
- ✓ Provision of Nutrition
  - IV therapy
  - TPN
- ✓ Nursing care is focused on supportive care:
  - assessment and monitoring.
  - suctioning (as needed),
  - optimum positioning.
  - minimal handling,

Adjunct Therapy (more commonly used for MAS)

- Inhaled nitric oxide (iNO)
- Extracorporeal membrane oxygenation (ECMO)

**Figure 7.2 Summary of x-ray findings per condition**

Condition	X-ray findings
<b>RDS</b>	Chest x-ray shows changes with a reticulo-granular pattern within the lung fields (or ground glass appearance) with some opacification.  An air bronchogram and low lung volumes will also be evident.
<b>TTN</b>	Chest x-ray will show fluid filled lungs within the major or minor fissures.  Normal to slightly hyper-inflated lungs.
<b>MAS</b>	Chest x-ray shows bilateral, coarse, patchy and widespread infiltrates.  There are also marked air trapping, hyper expansion, and hyperinflation

**Figure 7.3 Summary of common cardiovascular conditions**

<b>Conditions</b>	<b>Description</b>
<b>Patent ductus arteriosus</b>	Is the persistence of the vessel that links the main and left pulmonary arteries and the descending aorta.
<b>Patent foramen ovale</b>	Is the persistence and failure of the foramen ovale to close after birth. This will result to a left-to-right shunting which results in the mixture of both oxygenated and deoxygenated blood.
<p><b>Diagnosis</b></p> <ul style="list-style-type: none"> <li>○ ECG</li> <li>○ Nitrogen washout test (to determine if it is a respiratory or cardiac origin)</li> <li>○ Chest x-ray</li> <li>○ ECHO Cardiography</li> <li>○ Cardiac catheterisation (for examining the four chambers of the heart).</li> </ul>	
<p><b>Assessment</b></p> <ul style="list-style-type: none"> <li>• Neonates are often asymptomatic</li> <li>• Presence of a continuous machinery type murmur</li> <li>• Bounding pulses</li> <li>• A thrill upon palpation</li> <li>• Signs of pulmonary over circulation</li> </ul>	

**General management**

- ✓ Vascular access
- ✓ Provision of oxygenation
- ✓ Provision of nutrition
- ✓ Fluid therapy
- ✓ Inotropic support (maintenance of cardiac output or blood pressure)
- ✓ Blood glucose monitoring
- ✓ Fluid Balance monitoring including measurement of input and output.
- ✓ Control environment: temperature and pain assessment /management

**Figure 7.4 Summary of problems related to thermal homeostasis**

<p><b>Hypothermia</b>- According to WHO, 2007, Hypothermia could be classified as:</p> <ul style="list-style-type: none"><li>• 36 C to 36.4 C = mild hypothermia (cold stress)</li><li>• 32 C to 35.9 C = moderate hypothermia</li><li>• 32 C below = severe hypothermia</li></ul> <p><b>Hyperthermia</b>- Temperature above 37.5 C</p>
<p><b>Diagnosis</b></p> <ul style="list-style-type: none"><li>○ Temperature determination</li><li>○ Arterial Blood gas (to rule out hypoxemia and metabolic acidosis)</li><li>○ Full blood count (assess for sepsis)</li><li>○ Blood glucose level (assessment of hypoglycaemia)</li><li>○ Electrolytes, blood urea nitrogen (BUN), serum and urine osmolality (assessment of hydration, acid-base balance, and renal function)</li></ul>
<p><b>Assessment</b></p> <ul style="list-style-type: none"><li>• Pale, mottled, skin</li><li>• Cyanosis (Acrocyanosis / central)</li><li>• Respiratory distress</li><li>• Apnoea, bradycardia</li><li>• Change in consciousness (lethargy)</li><li>• Change in behaviour (irritability, hypotonia, weak cry and suck)</li><li>• Gastric residuals, abdominal distention, vomiting.</li><li>• Shivering in more mature babies</li><li>• Metabolic acidosis</li><li>• Hypoglycaemia</li><li>• Reddened and warm skin</li><li>• Changes in Vital signs (tachypnoea, Tachycardia, apnoea)</li><li>• Change in consciousness (lethargy)</li><li>• Change in behaviour (hypotonia, irritability, weak cry, and poor feeding)</li><li>• Sweating in more mature babies</li><li>• Dehydration</li></ul>

### **General management**

- ✓ Maintenance of neutral thermal environment and adequate nutrition, maintenance of blood glucose level and optimum oxygenation to prevent hypoxia (i.e. the 'metabolic (energy) triangle).

- Incubator
- Humidity
- Radiant warmer
- Heated mattress
- Polyethylene plastic wrap
- Transwarmer
- Skin to skin
- Clothing, hats, and blankets.
- Nest Infant Warmer (used in transfers)

**Table 7.5 Blood sugar imbalances**

Conditions	Description
<b>Hypoglycaemia</b>	<p>Is not a medical condition itself but a feature of an illness, poor / slow feeding, or a result of failure to adapt to extrauterine life. It occurs when the demand is higher than the available glucose supply.</p> <p>Threshold &lt; 2.5 mmols/L (BAPM, 2024) Older neonates &lt; 4-7mmols/L</p>
<b>Hyperglycaemia</b>	<p>May be a sign of a serious underlying disorder such as infection. Is associated with the incomplete production of insulin in immature neonates. It can also result from a high glucose production or infusion rate or low glucose uptake rate.</p> <p>&gt;8-10 mmols/L</p>
<p><b>Diagnosis</b></p> <ul style="list-style-type: none"> <li>○ <b>Blood tests:</b> <ul style="list-style-type: none"> <li>• Plasma glucose concentration (laboratory measurements)</li> <li>• Serum insulin concentration</li> <li>• Blood gas (including lactate).</li> <li>• Infection screen</li> <li>• Liver function</li> <li>• Blood clotting studies</li> <li>• Urea and electrolytes</li> </ul> </li> </ul>	

- Plasma fatty acids
- Plasma insulin/cortisol
- Plasma/urine amino acid profile
- Urine organic acids

**Other tests:**

- Ultrasound of the brain and adrenals
  - Ophthalmologic examination (for septo-optic dysplasia)
  - MRI, CT, PET (for structural anomaly)
- The various diagnostic tests are often conducted to rule out the main cause of hypoglycaemia. This is to ensure appropriate management is given to the neonate.

**Assessment**

**Hypoglycaemia:**

- Changes in level of consciousness:
  - Lethargy
  - Drowsiness
  - Coma

Changes in behaviour:

- Irritability
- Jitteriness
- Poor feeding
- Hypotonia

Changes in vital signs:

- Apnoea
- Bradycardia
- Hypothermia
- Sweating
- Bounding Pulses

**Hyperglycaemia:**

- Signs of weight loss and dehydration associated with the development of osmotic diuresis, Glycosuria, blood glucose measurements.

**General management**

- ✓ Early identification and careful monitoring of vital signs and glucose levels.  
Do check at local guidelines for variations in what they consider as the normal range / threshold.
- ✓ Seek and treat underlying disorders.

- ✓ For hypoglycaemia, early energy provision / early feeding /adequate nutrition, maintenance of neutral thermal environment.
- ✓ For hypoglycaemia, possible Glucagon if problem persists.
- ✓ When hyperglycaemic, rate of glucose infusion may be carefully reduced to the rate at which blood glucose levels become normal. Insulin infusion may be needed, carefully titrated to blood glucose levels.

**Figure 7.6 Summary of problems related to fluid balance**

<b>Conditions</b>	<b>Description</b>
<b>Fluid volume deficit (dehydration)</b>	Occurs when negative fluid balance is present. May be due to excessive weight loss, inadequate fluid intake, fluid shifts or medications
<b>Fluid volume excess (overload)</b>	Occurs when there is positive fluid balance. Positive fluid balance may lead to acute kidney injury, chronic lung disease, necrotising enterocolitis, and patent ductus arteriosus.
<b>Diagnosis</b>	
<ul style="list-style-type: none"> <li>○ Weight determination</li> <li>○ Laboratory findings: <ul style="list-style-type: none"> <li>• Sodium</li> <li>• Potassium</li> <li>• Haematocrit</li> <li>• Blood urea nitrogen (may indicate dehydration)</li> <li>• Creatinine (increased with renal failure)</li> <li>• Total CO<sub>2</sub> (indicates acidosis)</li> <li>• Serum osmolality</li> </ul> </li> <li>○ Urinalysis</li> <li>○ (Increased or decreased urine specific gravity)</li> <li>○ Chest -ray (may show extra fluid in lung fields, in fluid volume excess)</li> </ul>	
<b>Assessment</b>	
<b>Fluid deficit:</b>	
<ul style="list-style-type: none"> <li>• Maternal history (health conditions, medications, placental blood flow and fluid balance).</li> <li>• Neonatal history (presence of RDS, pneumonia, asphyxia, fluid balance, NEC).</li> <li>• Assessment</li> <li>• Vital signs</li> </ul>	



- Thready pulses
- Perfusion (Cappillary refill time (CRT) delayed, cool extremities)
- Signs of dehydration: (Lack of skin turgor, sunken fontanelle, dry mucous membrane, and absence of tears), oliguria, increased urine concentration, weight loss
- Change of behaviour / consciousness (decreased muscle tone, irritable or listlessness)

**Fluid overload:**

- Neonatal history (disease process).
- Assessment
- Vital signs
- Hear murmur
- Breath sounds (crackles, wheezing- signs of pulmonary congestion)
- Bounding pulses
- Oedema
- Change in level of consciousness
- Weight gain (acute)

O'Brien and Walker (2014).

**General management**

- ✓ Maintenance of fluid and electrolyte imbalance
- Fluid administration (including boluses for fluid deficit)
- Fluid restriction (when there is fluid excess)
- Use of central venous catheters
- ✓ Accurate input and output assessment and monitoring
- ✓ Assessment and monitoring of vital signs and changes in levels of consciousness.
- ✓ Regular monitoring of laboratory findings.
- ✓ Maintain NTE (minimise insensible water loss)
- ✓ Medication (diuretics in fluid volume excess)

**Nursing Care:**

- Positioning (to relieve discomfort due to oedema for fluid volume excess)
- Minimal handling
- Parent support and education

**Figure 7.7 Summary of problems related to the gastro-intestinal tract (gut)**

Conditions	Description
<b>Gastroesophageal reflux (GOR)</b>	Occurs when stomach contents back flows into the oesophagus, leading to irritation and discomfort. Often caused by under development of the neuromuscular control of the gastro-oesophageal sphincter. Common in preterm neonates and does not require investigation or treatment.
<b>Gastroesophageal reflux disease (GORD)</b>	Occurs when reflux causes more troublesome and persistent symptoms such as poor weight gain, discomfort, and ongoing regurgitation.
<b>Necrotising enterocolitis</b>	An acquired disease that attacks the G/I system characterized by ischaemic, inflammatory condition that causes bowel necrosis, perforation and even death.
<p><b>Diagnosis</b></p> <ul style="list-style-type: none"> <li>○ History &amp; feeding behaviour / discomfort with feeding</li> <li>○ Clinical manifestations – regurgitation</li> <li>○ <b>For GORD</b> as follows: <ul style="list-style-type: none"> <li>• Extended pH probe monitoring</li> <li>• Contrast studies (Upper GI/Barium Swallow)</li> <li>• Ultrasound of gastro-oesophageal junction</li> <li>• Radionuclide scan</li> <li>• Endoscopy</li> </ul> </li> <li>○ <b>For NEC</b> as follows:</li> </ul> <p><b>Laboratory</b></p> <ul style="list-style-type: none"> <li>• FBC (Thrombocytopenia, neutropenia, neutrophilia, anaemia)</li> <li>• U and E's (Hyponatremia, hyperkalaemia, high BUN)</li> <li>• Metabolic acidosis</li> <li>• hyperbilirubinemia</li> <li>• Elevated CRP</li> <li>• Coagulation abnormalities</li> </ul> <p><b>Radiologic Findings</b></p> <ul style="list-style-type: none"> <li>• Fixed loop of bowel with thickened intestinal wall</li> <li>• Pneumatosis and portal venous gas</li> <li>• Gasless abdomen or pneumoperitoneum</li> </ul>	
<p><b>Assessment</b></p> <ul style="list-style-type: none"> <li>• Regurgitation, vomiting (for GOR and GORD)</li> <li>• History &amp; clinical signs (see diagnosis section) / Clinical signs <b>for GORD</b> as follows: <ul style="list-style-type: none"> <li>• <b>S</b>-severe pain/discomfort</li> <li>• <b>T</b>-tissue damage / inflammation (oesophagitis)</li> <li>• <b>A</b>-aspiration Pneumonia</li> <li>• <b>F</b>-frequent vomiting.</li> <li>• <b>F</b>-faltering weight</li> </ul> </li> </ul>	

- **For NEC** as follows:

**Clinical signs:**

- Abdominal distension and tenderness, tense
- Occult or bloody stools
- High or retained gastric content.
- Shiny abdomen and abdominal wall oedema, discolouration of abdominal wall
- Palpable abdominal mass
- Absent bowel sound

**Non-specific signs:**

Change in behaviour and consciousness (lethargy, poor feeding)

- Bile stained vomits
- Jaundice
- Apnoea, Bradycardia, hypotension, temperature instability
- Hypoperfusion- signs of shock

Decreased urine output

## General management

- ✓ GOR will resolve itself.
- ✓ Nursing Care of GOR: Positioning, feeding regime alterations (mode of feeding delivery and frequency), comfort measures, pain and stress assessment (cue-based care)
- ✓ Medical Management of GORD: Antacids/ alginates, Proton Pump Inhibitors (PPIs), Prokinetic agents, possible surgery.
- ✓ Nursing Care of GORD: Positioning, feeding regime alterations (mode of feeding delivery and frequency), use of feed thickeners.
- ✓ Management & care of NEC: Secure and maintain airway, establish circulation (establish vascular access, intravascular volume replacement and correct metabolic acidosis), promote gut resting (NBM), support nutritional needs (Fluids / TPN), gastric decompression (large bore NGT/OGT), broad-spectrum antibiotics, regular monitoring (clinical, laboratory and radiographic), surgical (laparotomy), pain control and management, assessment and monitoring of symptoms, positioning for comfort, supportive developmental care, minimal handling.
- ✓ For all conditions- parent support and education.

**Figure 7.8 Summary of problems related to the immune system**

Conditions	Description
<b>Early onset infection</b>	-occurs within the first <48-72 hours of life -common source could be transmission via the vaginal or placental transfer. -common pathogens that causes the infection: Group B Streptococcus, E-coli, Coagulase-negative Staphylococcus (CONS)
<b>Late onset infection</b>	-occurs after 72 hours of life up even up to 1-3 weeks after birth -common source: postnatal environment (nosocomial), cross infection
<p><b>Diagnosis</b></p> <ul style="list-style-type: none"> <li>○ Full blood count</li> <li>○ -WBC (presence of neutropenia, neutrophilia, thrombocyte-paenia)</li> <li>○ CRP: raised</li> <li>○ Blood Culture</li> <li>○ Blood gas (with metabolic acidosis and BE &gt;8mmol/L hyperoxia, hypercapnia)</li> <li>○ Urine microscopy: (suprapubic catheterization to rule out UTI; urine dipstick for leucocytes and bacteria)</li> <li>○ Nasopharyngeal aspirates</li> <li>○ Chest x-ray</li> <li>○ Cerebrospinal fluid</li> <li>○ The variety of diagnostic tests are often used to rule out the main cause of infection to determine the type and course of antibiotic treatment.</li> </ul>	
<p><b>Assessment</b></p> <p><b>Red flag symptoms</b> (NICE, 2021)</p> <ul style="list-style-type: none"> <li>• <b>S</b>-seizures</li> <li>• <b>C</b>-CPR (the need for)</li> <li>• <b>A</b>-apnoea</li> <li>• <b>M</b>-mechanical ventilation</li> <li>• <b>S</b>-signs of shock</li> </ul> <p><b>Other clinical manifestation:</b></p> <ul style="list-style-type: none"> <li>• Altered behaviour, responsiveness, and muscle tone (floppiness).</li> <li>• Feeding difficulties and intolerance (vomiting, excessive gastric aspirates, and abdominal distension)</li> <li>• Abnormal heart rate (bradycardia or tachycardia)</li> <li>• Signs of respiratory distress (grunting, recession, tachypnoea)</li> <li>• Hypoxia (central cyanosis or reduced oxygen saturation level)</li> <li>• PPH of newborns</li> <li>• Jaundice within 24 hours of birth</li> <li>• Signs of neonatal encephalopathy</li> <li>• Temperature instability</li> <li>• Unexplained excessive bleeding, thrombocytopenia, or abnormal coagulation</li> <li>• Altered glucose homeostasis (hypoglycaemia or Hyperglycaemia)</li> <li>• Metabolic acidosis</li> </ul>	

## General management

- ✓ Antibiotic therapy
- ✓ Fluids therapy (colloids/crystalloids, volume)
- ✓ Inotropic support
- ✓ Maintain adequate oxygenation: (non-invasive respiratory support or mechanical ventilation)
- ✓ Transfusion
- ✓ Vitamin K
- ✓ Provision of nutrition (IV fluid, TPN)
- ✓ Correction of acidosis
- ✓ Immune modulation
- ✓ Nursing care is focused on supportive care:
  - assessment and monitoring, •optimum positioning; •minimal handling

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## Glossary

**Apnoea:** The absence of breathing.

**Bradycardia:** Slow heart rate.

**Brown fat:** Brown adipose (fat) tissue that is activated in times of cold stress to produce heat through increased metabolism.

**Congenital pneumonia:** An infection established during the foetal period, where the infection crosses the placenta to the unborn infant.

**Continuous positive airway pressure (CPAP):** A constant positive airway pressure either set at one level or two alternating levels, is applied to the airway of a spontaneously breathing neonate to maintain adequate functional residual capacity within the alveoli and prevent atelectasis.

**Endotracheal tube (ETT):** Small plastic tube that is inserted through the nose or mouth down through the larynx and into the trachea for full mechanical ventilation.

**Gestation:** The period of time between conception and birth.

**Hypoxia:** Deficiency in the amount of oxygen reaching the tissues.

**Jaundice:** The yellowing of the skin, mucous membranes, and the whites of the eyes that occurs when the body does not process bilirubin as it should resulting in hyperbilirubinaemia.

**Keratin:** Fibrous structural protein of epithelial cells in the stratum corneum of the skin.

**Lanugo:** Soft, thin hair that is found on the body of a foetus or newborn. It usually appears around sixteen weeks of gestation.

**Meconium aspiration:** Occurs when the newborn infant inhales a mixture of meconium and amniotic fluid.

**Metabolise:** A chemical process within the body to break down, absorb, and use an element.

**Non shivering thermogenesis:** A metabolic process, occurring in the brown fat to increase heat production.

**Palma creases:** Creases of the palm of the hand, usually three.

**Plantar creases:** Creases on the sole of the foot.

**Prematurity:** Relates to babies who are born alive before 37 weeks gestation.

**Pulmonary haemorrhage:** Bleeding into the lungs.

**Surfactant:** A substance that reduces the surface tension within the lung alveoli allowing them to expand in normal breathing.

**Thermoregulation:** The capacity to maintain homeostasis (balance) between heat production and heat loss to sustain the body temperature within a normal range.

**Total parenteral nutrition (TPN):** The administration of a nutritionally complete solution given intravenously when it is not possible to feed enterally.



**EXTRA READING** – Read more about the pathophysiology of common neonatal conditions....

- Gallacher D J, Hart K, Kotecha S (2016) **Common respiratory conditions of the newborn.** *Breathe.* 12(1):30-42.
- Reuter S, Moser C and Baack M (2014) **Respiratory distress in the newborn.** *Pediatr Rev.* (10):417-28;
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